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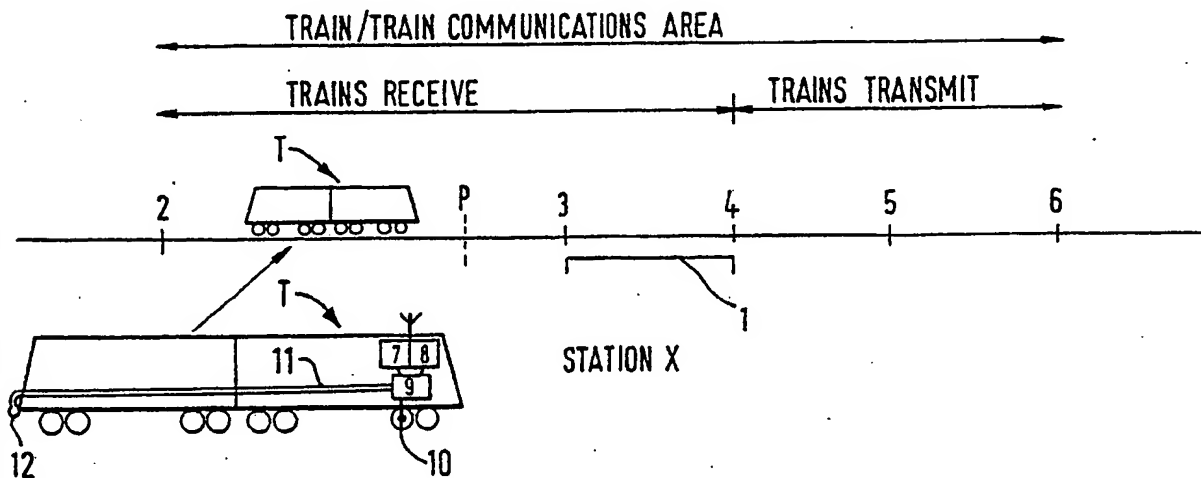
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(54) A railway signalling system.

(57) A railway signalling system is disclosed in which there is a combination of fixed block signalling with direct communication between separate trains or vehicles to achieve inter-vehicle spacing. The fixed block signalling prevents more than one train (or vehicle) from transmitting and more than one train (or vehicle) from acting upon communications relative to a given area or portion of line.

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## A RAILWAY SIGNALLING SYSTEM

The present invention relates to a railway signalling system.

The concept of arranging for the rear of a leading train of vehicles (or a leading vehicle) to send a signal directly to the front of a following train (or vehicle) for the purpose of controlling the speed of the latter and thus maintaining a safe distance between them is well known, but known systems using analogue signal measurement have not been of practical application to railways because of tolerancing and other difficulties. The concept of using digitally encoded messages is an obvious extension of known techniques. However, difficulties arise with message security in ensuring that messages are only received by the train (or vehicle) for which they were intended.

According to the present invention, there is provided a railway signalling system in which there is fixed block signalling in combination with direct communication between separate trains or vehicles to achieve inter-vehicle headway spacing; the fixed block signalling preventing more than one train (or vehicle) from transmitting and more than one train (or vehicle) from acting upon communications relative to a given area or portion of railway line.

Known systems of direct train to train communication claim to be better than systems based on fixed block sections, which are seen as a limitation on headway. However, by using the present invention, the retention of an underlying system of fixed blocks in conjunction with an appropriate form of direct train to train communication overcomes the practical difficulties of known systems and, moreover, provides for economy and simplicity compared with known systems. It also enables a reasonable mode of operation to be maintained during partial failure conditions, and enables later addition of the inter-vehicle headway spacing aspect to a basic fixed block system, whether the latter is based on conventional track circuits, inductive loops or similar, or on a radio-cab signalling system using transponders or other markers.

Known systems generally describe achievable headway by reference to application to a plain railway line without stations or other cause to stop. In practice, headway is usually dominated by station stops and junction working, including that at termini. It is well known that headway at stations is critical and for this reason conventional signalling equipment is often concentrated around stations.

To put the present invention into practice, because headway is critical at stations, it is practical and economical to achieve the best possible headway by adopting a system which allows the closest possible monitoring of a train (or vehicle) leaving a

station by a train (or vehicle) approaching the station using direct vehicle to vehicle communications, but which prevents any further train (or vehicle) entering the area and acting upon the same communications by known forms of fixed block signalling. Because thereby only one train (or vehicle) is permitted to monitor the location of a train (or vehicle) ahead and only one such train (or vehicle) ahead may be reporting its location via the vehicle to vehicle communications system within a given area, it is not necessary for either train (or vehicle) to know the identity of the other nor for the message from the leading train (or vehicle) to be directed to the following train (or vehicle) by an intelligent supervisory system. The fixed block system will prevent any third train or vehicle breaking into communications between two trains or vehicles. In the areas of plain railway line away from stations, fixed block signalling alone is adequate to maintain the optimum headway which is achieved around stations by using vehicle to vehicle communication in addition. In the event of a vehicle to vehicle communications failure, the fixed block system also provides a back-up mode of operation albeit with degraded headway performance.

The present invention will now be described, by way of example, with reference to the single figure of the accompanying drawing, which is a schematic representation of an example of the present invention.

Referring the drawing, a railway line L in the vicinity of a station X with a platform 1 is divided into a number of fixed block sections with boundaries 2, 3, 4, 5 and 6.

Boundary 2 corresponds with the position at which a train T has to receive its first warning that a preceding train is occupying the platform 1, in order to be guaranteed to stop short of boundary 3 (which corresponds to the end of the platform, just ahead of which will be the tail of any train stationary in the platform). The distance from boundary 2 to boundary 3 is therefore braking distance plus the usual allowances for equipment reaction time, etc. Until a train reaches boundary 2, there is no need for it to be aware of the precise position of a preceding train provided the latter is beyond boundary 3, and this is determined by fixed block signalling. Prior to the preceding train passing boundary 3, a fixed block signalling system gives adequate headway capacity in rear because the train is about to stop at the station and any following train must clearly be much further than braking distance behind (or itself performing a station stop in rear) if it is to run unchecked. On passing boundary 2, the front of a train also enters an area

of train to train communication extending from boundary 2 to boundary 6. Such communication may be achieved by means of a leaky feeder radio system extending from boundary 2 to boundary 6 which broadcasts on one frequency the message received on another without modification or delay. Alternatively, any other suitable communications medium such as an inductive track loop may be used. While the front of a train is between boundaries 2 and 4, the train may receive train to train messages from a train ahead within the same area by means of a train carried radio receiver 7 at the front of the train. Boundary 4 is at a point immediately ahead of the location of the front of a train when stationary in the platform 1. While the front of a train is between boundaries 4 and 6 it may transmit train to train messages for the area to a following train by means of a train carried radio transmitter 8. The transmission system may be split at boundary 4 if required and as shown, the section from boundary 2 to boundary 4 being for transmission to trains (i.e. trains receive) and the section from boundary 4 to boundary 6 being for reception from trains (i.e. trains transmit). The train to train messages consist of a continuously updated report of the location of the leading train's tail.

Boundary 5 is located at the point beyond which the presence of a train will no longer be restrictive to the running of a following train which is stopping at the station X. Boundary 6 is located at normal maximum train length beyond boundary 5. When the front of a train passes boundary 6, its authority to transmit for that area will cease (as will the means of communication). As this corresponds to the train's tail being clear of boundary 5, the actual position of the train tail is no longer relevant to a following train stopping at the station X.

Each train T has an on board train computer 9 used for automatic train control in conjunction with the fixed block signalling system which can be, in principle, of known type. It may employ transponders for location reference and radio messages for movement authorities or it may be coded track circuit based. In either case, the train computer 9 supervises train running in accordance with speed/distance profiles selected according to fixed data concerning train performance and variable data concerning movement authority limits, where the variable data is derived from the fixed block movement authority messages or "proceed aspects" as in known systems. To ensure that train speed is within profile limits, the train computer must have knowledge of speed and of distance travelled from fixed reference points and this is generally achieved as in known systems by means of an odometer, tachometer or equivalent arrangement 10. This locational reference may also be

used by the example of the present invention as the basis for train to train reporting of train tail location, in conjunction with a train line 11 and train rear device 12 to confirm that the train is complete and does not exceed the normal maximum train length (for example because it is being pushed out by an assisting train after failing). The device 12 may be a simple electrical connection on the rear cab coupler on fixed formation train sets which is broken if a further vehicle is coupled on.

If running with intermediate cabs is required in normal service, a more elaborate means of train length measurement will be required. In the case of a track circuit based system, the station platform track circuit in the section from boundary 3 to boundary 4 can be used to check that the train does not exceed the normal maximum length. The fixed block system does not allow a second train to be between boundaries 2 and 3 until the tail of the train ahead has passed boundary 3, and unless short, a train could not be fully in the platform and hence clear of boundary 3 until a preceding train had cleared boundary 5. It is not therefore unduly restrictive to prevent a train entering the section from boundary 2 to boundary 3 until the section from boundary 4 to boundary 5 has been registered as clear, if the section from boundary 3 to boundary 4 is occupied. This control will ensure that, provided the train at the platform is no longer than the normal maximum length, there will be a brief period when the sections from boundaries 2 to 3 and 4 to 5 are clear with the section from boundary 3 to boundary 4 occupied and this can be registered to allow subsequent train to train communications to be acted upon. If the train length exceeds normal maximum, the train to train communication aspect of the example cannot be used, as knowledge of the location of the train front does not imply the correct location of the train rear. Normal maximum train length corresponds to the length of the section from boundary 3 to boundary 4. Alternatively, and in the case of non track circuit based systems, a form of train length measurement as proposed in our co-pending Patent Application No. of the same date as the present application and entitled "Computing the length of a railway vehicle or train of such vehicles" may be used. As a further alternative, train tail location may be deduced by the train computer by reference to the detection by rear of train mounted equipment (which may be the same equipment used for front of train location or other purposes when the train is driven in the opposite direction) of trackside markers such as transponders. Additionally the whole of the train tail location system and the train to train communications transmitter may be located at the rear of the train.

The authority to transmit train to train mes-

sages of train tail location may be derived from information contained within the movement authority message from the fixed block signalling system for the blocks concerned (the sections from boundary 4 to boundary 5 and boundary 5 to boundary 6 in the drawing). Authority to receive and act upon train to train messages of train tail location may similarly be incorporated within the movement authority message from the fixed block signalling system for the blocks concerned (the sections from boundary 2 to boundary 3 and boundary 3 to boundary 4 in the drawing). In both cases, confirmation that train length does not exceed normal maximum may be incorporated in the appropriate controls on movement authorities. Trains which exceed normal maximum length will be signalled by the fixed block signalling system but without the additional train to train communication aspect, and hence cannot be followed at minimum headway.

By way of further illustration, a sequence of train movements through the area of station X will now be considered with reference to three trains, A, B and C. Assume that: train B is at the station platform between boundaries 3 and 4; train C is approaching boundary 2; and the section from boundary 4, to boundary 5 is clear but train A is still in the section from boundary 5 to boundary 6. The movement authority for train C for the section from boundary 2 to boundary 3 has an end point defined as boundary 3. (The train would normally stop at some point P which, depending on the ratio of service to emergency braking, may be close to boundary 3). There is no point in train C being authorised to receive train to train messages at this stage because train B cannot leave the station until train A is clear of boundary 6. By not giving train C authority to act on train to train messages it cannot erroneously act on messages from train A which may be received until the front of train A passes boundary 6. When the front of train A passes boundary 6 its transmit authority is lost and it cannot send further train to train messages for the area. When the tail of train A passes boundary 6, the fixed block system detects this and updates the authority for the section from boundary 2 to boundary 3 to permit actioning of train to train messages. Because train A is beyond boundary 6 there is no further risk of train C erroneously receiving transmissions from train A because, firstly, train A lost authority to transmit on passing boundary 6 and, secondly, train A is completely beyond the limit of the communications system and therefore, in practice, out of range.

The updated authority for the section from boundary 2 to boundary 3 allows the end point of the stopping profile used by the train computer of train C to be modified from a default corresponding to boundary 3 according to train to train messages

of train tail location which are given in terms of a distance which is interpreted as relative to boundary 3. When train B departs from the station X on a fixed block movement authority which requires the sections from boundary 4 to boundary 6 (and sections beyond as appropriate) to be clear, it enters the section from boundary 4 to boundary 5. The authority in this section (and the section from boundary 5 to boundary 6) includes authority to transmit on the train to train communications system the distance travelled past boundary 4. As train B proceeds it therefore transmits a continuously updated digital message corresponding to a count of distance travelled past boundary 4. This is received by train C and interpreted as a continuously updated message of the distance which the train ahead's tail is beyond boundary 3 (to which it is equivalent). For the headway critical period as train B is leaving the station and train C is approaching, train C is therefore aiming the end point of its stopping profile at the location of the tail of train B, as continuously amended, and the closest possible headway is therefore achieved over the critical area.

If by the time the front of train C passes boundary 3, train B has not completely cleared the section from boundary 3 to boundary 4, the train computer on train C will allow the train to continue to run on an extension of the profile authorised in the section from boundary 2 to boundary 3 as long as train tail messages are being received, to a limit corresponding to a train length beyond boundary 3, equivalent to the location of boundary 4. When train B clears the section from boundary 3 to boundary 4, the fixed block system will confirm a movement authority for this section as far at least as boundary 4 and as may be extended by train tail messages, to a limit corresponding to the location of boundary 5. When train B clears the section from boundary 4 to boundary 5, the fixed block system will give a movement authority for the section from boundary 3 to boundary 4 with an end point at boundary 5 absolutely, to which train C can now aim the end point of its profile without reference to further train to train messages. It will also correspondingly upgrade the movement authority for the section from boundary 2 to boundary 3 if train C has not yet passed boundary 3. These authorities allow a run which is unrestricted by train B ahead, for train C to approach and stop at the station. As explained for train A, the front of train B then passes boundary 6 and train B stops transmitting train to train messages.

It is obviously essential that there is no possibility of cross-talk between adjacent communications areas, which may have to overlap. Where adequate isolation of adjacent area communications cannot be achieved, then different frequen-

cies and a different address may be used for train to train communications in adjacent areas. Frequencies and addresses may be used more than once, typically in alternate areas provided isolation is adequate. Information as to which frequency and address is current will be obtained from trackside transponders or equivalent, read by the train computer, or will be incorporated in relevant proceed authorities.

Communications areas may overlap in such a way that the same boundaries and fixed block sections have different functions in relation to different areas and, in the limit, an application where there is continuous train to train communications over a section of line consisting of several areas could be arranged. Such an application would be simpler in principle and much more fault tolerant than other known systems of close headway working, due to the underlying fixed block basis of control.

## Claims

1. A railway signalling system in which there is fixed block signalling in combination with direct communication between separate trains or vehicles to achieve inter-vehicle headway spacing, the fixed block signalling preventing more than one train (or vehicle) from transmitting and more than one train (or vehicle) from acting upon communications relative to a given area or portion of railway line.

2. A system as claimed in claim 1, wherein the fixed block signalling uses track circuit signalling.

3. A system as claimed in claim 1, wherein the fixed block signalling uses radio signalling.

4. A system as claimed in any preceding claim, wherein the authority to transmit, receive and act upon vehicle to vehicle communications is contained in fixed block movement authorities.

5. A system as claimed in claim 4, wherein said block movement authorities are given by track circuit code, radio, inductive loop or other means with or without fixed information read from trackside transponders, beacons, loops or the like.

6. A system as claimed in any preceding claim, wherein the direct vehicle to vehicle communication messages convey the location of the tail of a train (or vehicle) expressed as a distance which is interpreted as being beyond a particular reference point.

7. A system as claimed in any preceding claim, wherein the direct vehicle to vehicle communication is by radio or inductive loop.

8. A system as claimed in any preceding claim, wherein, on a train (or vehicle), functions are controlled by a train (or vehicle) computer at the front of the train (or vehicle) or divided between front and tail end equipment of the train (or vehicle).

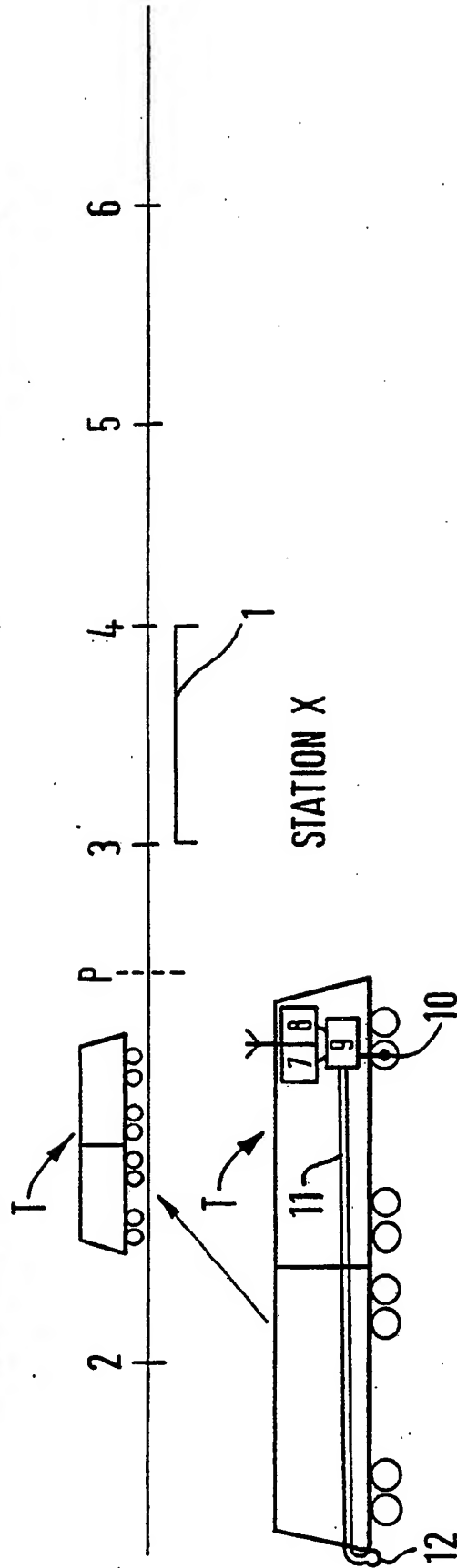
9. A system as claimed in any preceding claim, wherein the tail location of a train (or vehicle) is deduced and monitored.

10. A system as claimed in claim 9, wherein the tail location of a train (or vehicle) is deduced and monitored by a train (or vehicle) line or a train (or vehicle) tail device.

TRAIN/TRAIN COMMUNICATIONS AREA

TRAINS RECEIVE

TRAINS TRANSMIT



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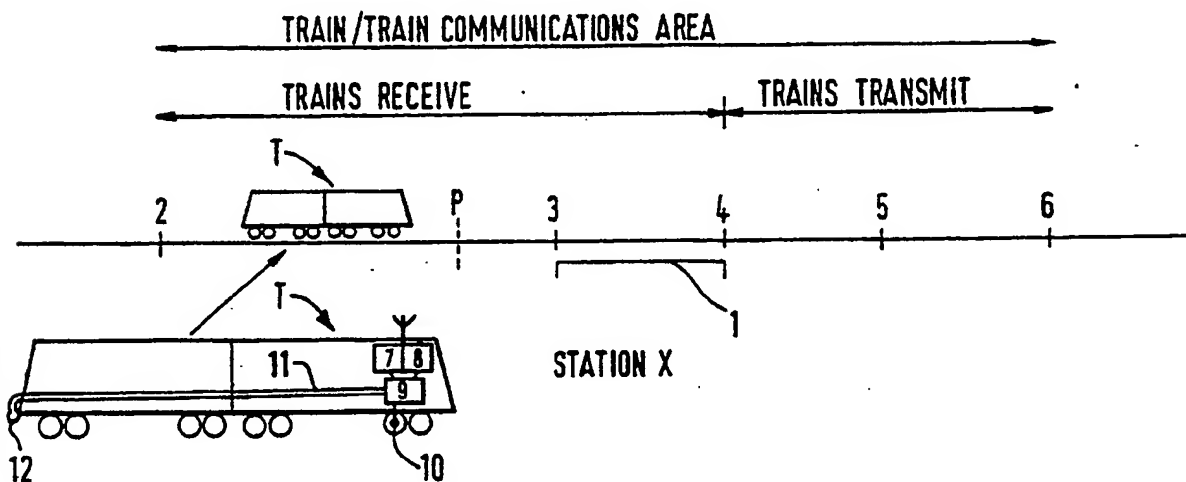
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-3 681 597 (MORLEY) * Column 2, line 36 - column 3, line 32; figure 1 *	1	B 61 L 21/10
A	US-A-2 762 913 (JEPSON) * Claim 1 *	1	
A	EP-A-0 188 925 (MATRA) * Abstract *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 61 L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-10-1990	Examiner SGURA S.
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			